

Species Diversity, 1998, 3, 133–154

The Genus *Protonemura* in Japan (Insecta: Plecoptera: Nemouridae)

Takao Shimizu*

Laboratory of Entomology, Tokyo University of Agriculture, 1-1-1 Sakuragaoka, Setagaya-ku, Tokyo 156, Japan

(Received 14 March 1997; Accepted 5 December 1997)

The Japanese species of *Protonemura* are treated, and the differential characters of each are illustrated. Besides four previously known species, *P. curvata* Zhiltzova, 1981 (new to Japan), *P. ermolenkoi* Zhiltzova, 1982 (new to Japan, and first description of the female), *P. hotakana* (Uéno, 1931), and *P. towadensis* (Kawai, 1954) (first description of the female), eight species are described as new to science: *P. angulata*, *P. baumanni*, *P. excavata*, *P. hakkodana*, *P. kohnoae*, *P. orbiculata*, *P. seticollis*, and *P. strumosa*. They are assigned to four groups by similarities of the male terminalia, and a key to the groups is given. In addition, one undetermined female of this genus is recorded from Okinawa Island, southwest Japan, and is illustrated.

Key Words: Plecoptera, Nemouridae, *Protonemura*, new species, new record, Japan.

Introduction

The diagnostic features of the genus *Protonemura* Kempny, 1898 are the deeply forked outer cervical gills and simple inner cervical gills in both nymphs and imagoes and a well developed subgenital plate and vaginal lobes in the females (Baumann 1975). Besides the type of gills, the presence of setae on tergite VIII and preceding segments in the male also seems to be an autapomorphy of the genus. This genus is considered as the sister group of *Mesonemoura* Baumann, 1975 plus *Indonemoura* Baumann, 1975 (see Baumann 1975). However, it looks more closely related to *Indonemoura*; the condition of the subgenital plate and vaginal lobes seems to be synapomorphic for *Protonemura* and *Indonemoura*, and so does the developed tigellus in the male paraproct.

About 100 species of *Protonemura* Kempny, 1898 are known and they have been recorded throughout the Palearctic Region. In Japan, seven species were recognized in the checklist of Kawai (1976), but all of the species described as new in the subgenus *Protonemura* (now raised to generic level) by Okamoto (1922) have been referred to other genera: *P. nohira* to *Indonemoura* (by Shimizu 1994a); and *P. chinonis*, *P. longicercia*, and *P. jezoensis* to *Nemoura* (by Shimizu 1994b). Moreover, *Nemoura* (*Protonemura*) *spinosa* Kawai, 1960 must be renamed, because it is a primary homonym of *Nemoura spinosa* Wu, 1929; This will be done, and the species transferred to *Amphinemura*, elsewhere (Shimizu, in press). Therefore, only two species are actually recognized from Japan: *P. hotakana* (Uéno, 1931) and *P. towadensis* (Kawai, 1954).

In the present paper, the differential characters of all the species of *Protonemura* obtained from Japan are illustrated and described; eight species are new to science

*Present address: Aqua Restoration Research Center, Ministry of Construction, Kasada, Kawashima-cho, Gifu, 501-6021 Japan

and two species are recorded as new to Japan. The interrelationships of the Japanese species are discussed, and four species groups are proposed for them except for an undetermined female collected in Okinawa Island, southwest Japan.

Terminology and Materials

Morphological terms follow Baumann (1975), and some of them are labelled in figures 1, 4, 7, and 18. The following abbreviations of depositories are used: Department of Biology, Nara Women's University (NUW), Nara, Japan; Lake Biwa Museum (LBM), Kusatsu, Japan; Brigham Young University (BYU), Provo, Utah, USA. All of the specimens examined are preserved in 70-80% alcohol, and the collector's name is omitted from the material collected by me in the following lists.

Affinities of the Japanese *Protonemura*

The species of *Protonemura* are generally similar to one another, and defining groups based on derived characters is difficult. However, the Japanese species can be assigned to four groups by the diagnostic keys for male terminalia given below, except for one undetermined female from Okinawa Island. No similar species have been known from Korea and China, and all four groups appear to be restricted to only Japan, or to Japan and the Russian Far East.

Key to the Groups of *Protonemura* from Japan

1. Epiproct with wide, rounded, horizontal excavation on dorsal face near apex, latter with small internal hook extending ventrally; cerci almost cylindrical; paraproct with tigellus directly extending from apex of median lobe *P. curvata* group
- Epiproct grooved or depressed on dorsal face along midline, apex extending dorsoapically; cerci suboval; paraproct with tigellus on inner side of median lobe or lacking 2
2. Epiproct simple, with dorsal face almost flat but weakly depressed near apex, latter with short, conical flagellum *P. hotakana* group
- Epiproct distinctly upturned at apex, latter with long, filamentous flagellum or poorly developed (nearly indiscernible) one 3
3. Epiproct with long, bifurcate flagellum at apex, deeply and narrowly grooved along midline of dorsal face, which is strongly depressed near dorsally recurved apex; male paraproct with long, stout tigellus on inner side of median lobe *P. orbiculata* group
- Epiproct with dorsomedial groove anteriorly, this becoming shallow and indistinct posteriorly; dorsal face almost flat but abruptly depressed by horizontal line near dorsally recurved apex; paraproct lacking tigellus (except short one in *P. towadensis*) *P. towadensis* group

1) The *P. curvata* group includes: *P. curvata* Zhiltzova, 1981 (from southern Kuril Islands and Hokkaido) as well as *P. excavata* sp. n. and *P. strumosa* sp. n. (both from

Hokkaido). All three species emerge in the spring and are common in streams. The group may be synonymous with or closely related to some European forms of *Protonemura*, e. g., the *P. intricata* (Ris 1902) species-group *sensu* Aubert (1956) inside the *P. lateralis* (Pictet 1836) species-group *sensu* Aubert (1946), based on common features of the epiproct: i) horizontally hollowed dorsal face, and ii) downturned recurved apex. However, no similar species are recorded from East Asia outside Japan and the Russian Far East.

2) The *P. hotakana* group includes two species: *P. hotakana* (Uéno, 1931) and *P. hakkodana* sp. n., both from Japan. Both species emerge in the autumn and are common in mountain streams.

3) The *P. orbiculata* group includes: *P. angulata* sp. n., *P. orbiculata* sp. n., *P. seticollis* sp. n., and *P. baumanni* sp. n., all from Japan. All four species emerge in the early spring, but adults of *P. seticollis* are found in both spring and autumn.

4) The *P. towadensis* group includes: *P. towadensis* (Kawai, 1954) and *P. kohnoae* sp. n. (both from Honshu) and *P. ermolenkoi* Zhiltzova, 1982 (Sakhalin, southern Kuril Islands, and Hokkaido). These species emerge in the autumn and/or spring and are common in mountain streams.

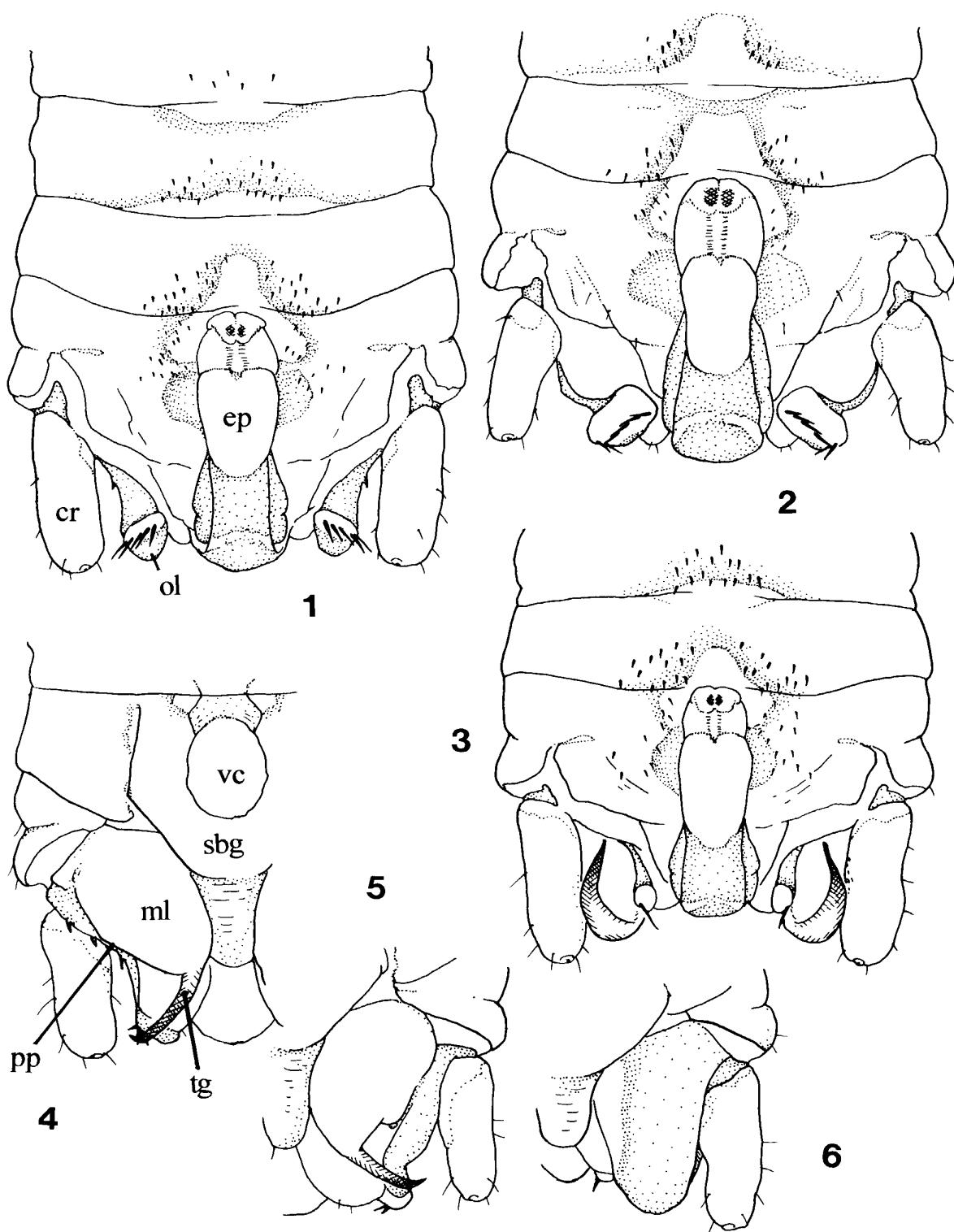
***Protonemura curvata* group**
***Protonemura curvata* Zhiltzova, 1981**
 Figs 1, 4, 7, 10

Protonemura curvata: Zhiltzova 1981: 84, figs A-C [Holotype ♂, Kunashir Island, southern Kuril Islands]; Zhiltzova and Zapekina-Dulkejt 1986: 212 (key).

Wings subhyaline; veins dark brown. General color brown: head, pronotum, and pterothorax mostly brown. Legs: coxae brown; trochanters light brown; femora mostly yellowish brown, each with slightly darker lines on dorsal face and either side, and hind femora with brown areas distally; tibiae yellowish but darker at base; tarsi brown.

Male. Abdomen mostly membranous except terminalia (= segments IX and X), but each tergite weakly sclerotized anteriorly. Tergite VII sometimes with few to several posteromedial setae; tergites VIII and IX sclerotized, each with many short setae around posteromedial membranous field. Tergite X concave under apex of epiproct, and bearing short setae around membranous field anterior to concavity. Sternite IX with stout vesicle; subgenital plate subpentagonal with bluntly elongated apex. Cerci long, cylindrical. Paraprocts: median lobe suboval and convex, with long caudal tigellus extending posterolaterally; outer lobe elongated inward and upward to dilated apex, bearing few to several setae along posterolateral edge and several setae at apex. Epiproct slender, roundly hollowed near apex, latter with small, ventrally recurved hook; ventral sclerite wide near base and then tapered to apex. Body length 6.0-6.5mm; forewing length 7.5-8.0mm.

Female. Pregenital plate of moderate size, often protruding posteriorly in middle of hind margin, and latter convex or roundly angular. Subgenital plate expanded posteriorly, shallowly grooved along midline; hind margin almost smooth and weakly convex. Vaginal lobes large and weakly convex. Body length 6.0-7.5mm; forewing length 8.0-9.0mm.



Figs 1-6. Male terminalia, dorsal (1-3) and ventral (4-6) views: 1 and 4, *Protonemura curvata* Zhiltzova; 2 and 5, *P. excavata* sp. n.; 3 and 6, *P. strumosa* sp. n. Abbreviations: cr, cerci; ep, epiproct; pp, paraproct (ml and ol, median and outer lobes); sbg, subgenital plate; tg, tigellus; vc, vesicle.

Remarks. This species closely resembles *P. excavata* sp. n. and *P. strumosa* sp. n., but the male is distinct from their males in having differently shaped paraprocts. The male also differs from that of *P. excavata* in the shape of the epiproct; i.e., its subapical hollow is narrower. The female is separable from those of the other two species by the shape of sternites VII and VIII; that of *P. strumosa* has swollen vaginal lobes and that of *P. excavata* has a larger pregenital plate.

Specimens examined. [Rishiri Island] Higashino-dottumari-gawa, Nozuka, 19.v-11.vii.1995, M. Sato, Malaise trap, 48♂ 48♀. [Hokkaido] Sapporo-shi: Asari-tōge, 700m, 13.vi.1992, 1♂ 1♀; Misumai, 24-30.vi.1992, N. Kuhara, 1♂; Kumaishi-chō: Kenichi-gawa, 1-16.v.1995, Y. and T. Ito, Malaise trap, 8♂ 21♀; Akan-chō: Pirinekappu, 9.vi.1992, 7♂ 23♀; Chūrui-gawa, 9.vi.1992, 4♂; Shikaoi-chō: Shikaribetsu-ko, Yanbetsu-gawa, 10.vi.1992, 2♂; Erimo-chō: Utabetsu, 5.vi.1992, 9♂ 10♀; Shimamaki-mura: Mt. Kariba, 700m, 19.vi.1991, 3♂; Otaru-shi: Asahi-gawa, 500m, 8.v.1990, N. Kuhara, 3♂ 1F♀. (New to Japan.)

***Protonemura excavata* sp. n.**

Figs 2, 5, 8, 11

Similar in general respects to *P. curvata* as described above, but different in the following characters:

Male. Cerci long, subcylindrical but slightly tapered. Paraprocts: median lobe suboval and convex, with long, outstretched caudal tigellus; outer lobe elongated inward and upward, its apex angularly swollen, dorsally membranous, and bearing 6-9 setae along inner edge. Epiproct slender, more widely hollowed near apex than in *P. curvata*. Body length 6.0-6.5mm; forewing length 7.5-8.0mm.

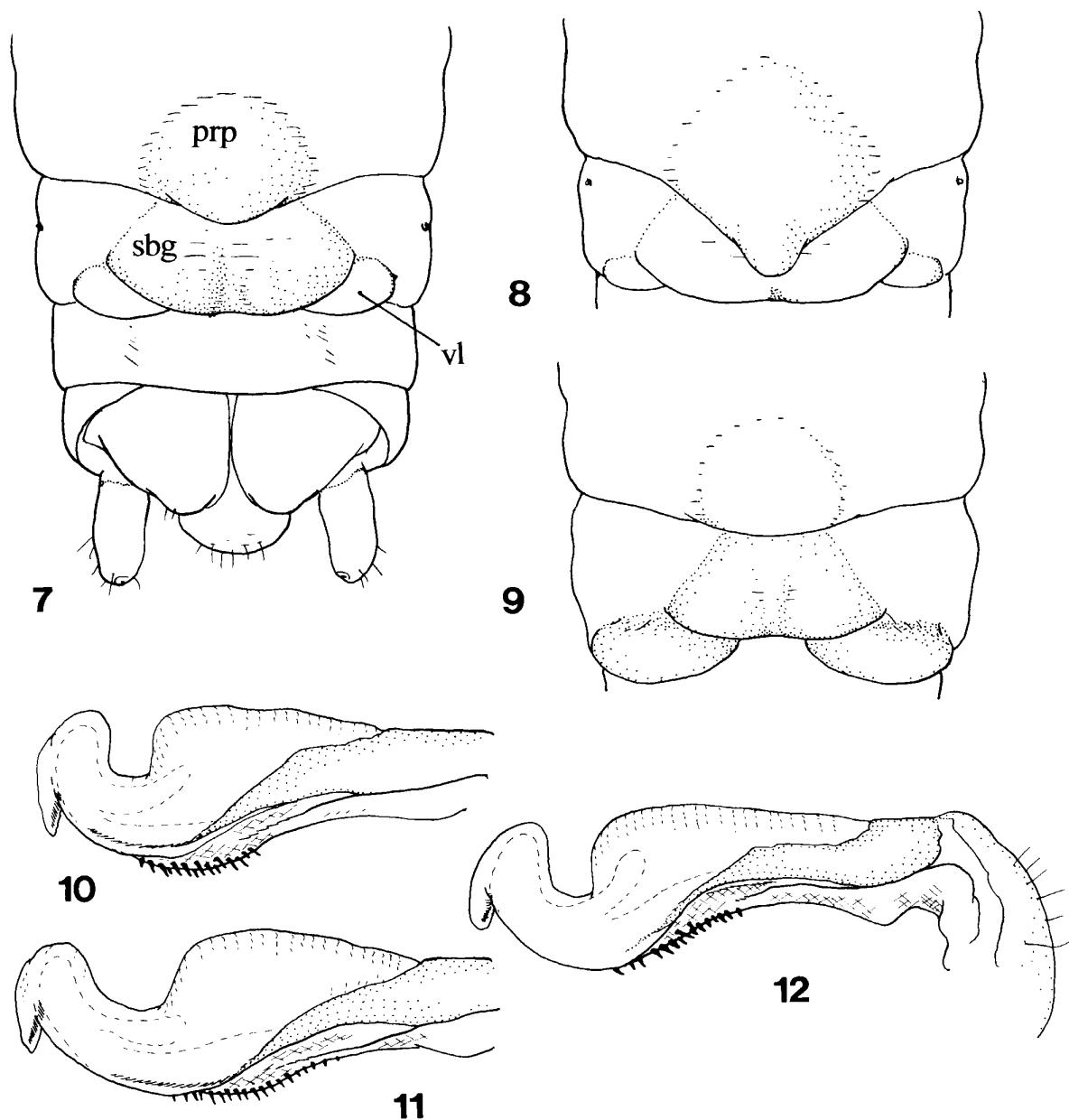
Female. Pregenital plate expanded, distinctively protruded and somewhat elevated in middle of hind margin. Subgenital plate large, weakly convex on either side of midline and with almost flat hind margin; vaginal lobes small and mostly concealed by subgenital plate. Body length 6.0-7.5mm; forewing length 8.0-9.0mm.

Remarks. The species closely resembles *P. curvata* and *P. strumosa* sp. n., but the male differs in having an angularly swollen apex of the paraproct and an epiproct with a wider subapical hollow. The female is separable from those of the other two species in having a large pregenital plate that protrudes considerably posteriorly.

Holotype. ♂ (LBM), Hokkaido, Urakawa-chō, Niobetsu-gawa, 400m, 5.vi.1992. **Paratypes.** 6♂ 19♀ (LBM); collected with holotype.

Additional specimens. [Hokkaido] Sapporo-shi: Hiyamizu-sawa, 450m, 20.vi.1991, 1♂ 5♀; Misumai, 24-30.v.1992 and 4-11.vi.1992, N. Kuhara, Malaise trap, 21♀; Shikaoi-chō: Shikaribetsu-ko, Yanbetsu-gawa, 10.vi.1992, 1♂ 1♀; Shimamaki-mura: Mt. Kariba, 700m, 19.vi.1991, 1F; Yūbari-shi: Akashi, 7.vi.1992, 1♂; Obihiro-shi: Tottabetsu-gawa, 340m, 10.vi.1992, 1♀.

Etymology. The name is a Latin adjective, *excavatus*, meaning hollowed and referring to the shape of the epiproct.



Figs 7-9. Female terminalia (or sternites VII and VIII), ventral view: 7, *Protonemura curvata* Zhiltzova; 8, *P. excavata* sp. n.; 9, *P. strumosa* sp. n. Abbreviations: prp, pregenital plate; sbg, subgenital plate; vl, vaginal lobe. Figs 10-12. Apex of male epiproct, lateral view: 10, *P. curvata* Zhiltzova; 11, *P. excavata* sp. n.; 12, *P. strumosa* sp. n.

***Protonemura strumosa* sp. n.**

Figs 3, 6, 9, 12

Similar in general respects to *P. curvata* as described above, but different in the following characters:

Male. Cerci long, subcylindrical but slightly tapered. Paraprocts: median lobe oblong and expanded posteriorly in ventral view, then recurved upward and tapered to an acute tip; outer lobe slender, elongated inward and upward, small blunt apex

bearing one to several setae. Epiproct slender, deeply hollowed near apex. Body length 6.0-7.5mm; forewing length 7.0-8.0mm.

Female. Pregenital plate small, weakly sclerotized, its surface almost flat. Sternite VIII with small, dilated subgenital plate; vaginal lobes considerably swollen and bulging. Body length 6.5-9.0mm; forewing length 7.5-9.5mm.

Remarks. This species closely resembles *P. curvata* and *P. excavata* sp. n., but the male is distinguished by the median lobe of paraproct, which is subquadrate in ventral aspect. The female is separable from those of the other two species by its distinctively swollen vaginal lobes.

Holotype. ♂ (LBM), Hokkaido, Obihiro-shi, Tottabetsu-gawa, 340m, 10.vi.1992.

Paratypes. 3♂ 19♀ (LBM), collected with holotype.

Additional specimens. [Hokkaido] Urakawa-chō: Niobetsu-gawa, 5.vi.1992, 4♂ 7♀; Hidakahorobetsu-gawa, 6.vi.1992, 1♀; Akan-chō: Pirinekappu, 9.vi.1992, 2♂; Shizunai-chō: Petegari-dake, 6.vi.1992, 1♂; Shizunai-gawa, 6.vi.1992, 2♀; Shikaoi-chō, Shikaribetsu-ko, 10.vi.1992, 3♂ 1♀.

Etymology. From the Latin adjective *strumosus*, meaning swollen, in reference to the shape of the vaginal lobes.

Protonemura hotakana group

Protonemura hotakana (Uéno, 1931)

Figs 13-15, 19-23

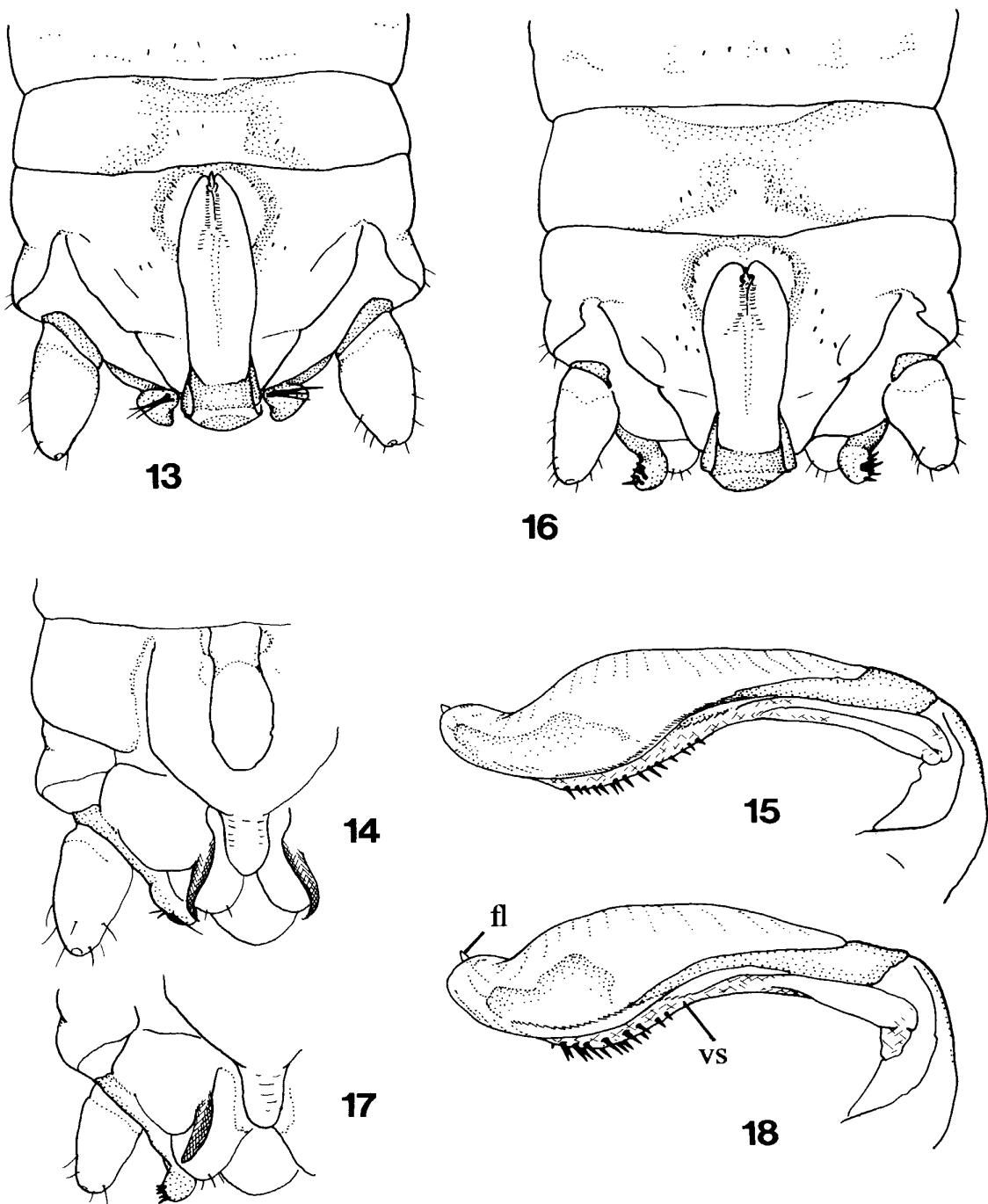
Nemoura (Protonemura) hotakana: Uéno 1931: 101, figs 7-8 [Holotype M (missing), Kamikōchi, Nagano, Japan]; Kohno 1957: 4 (checklist); Kawai 1960: 119 (key and additional records).

Nemoura hotakana: Claassen 1940: 56 (catalogue).

Protonemura hotakana: Illies 1966: 230 (catalogue); Kawai 1967: 13 (key and redescription of female); Kawai 1976: 19 (checklist).

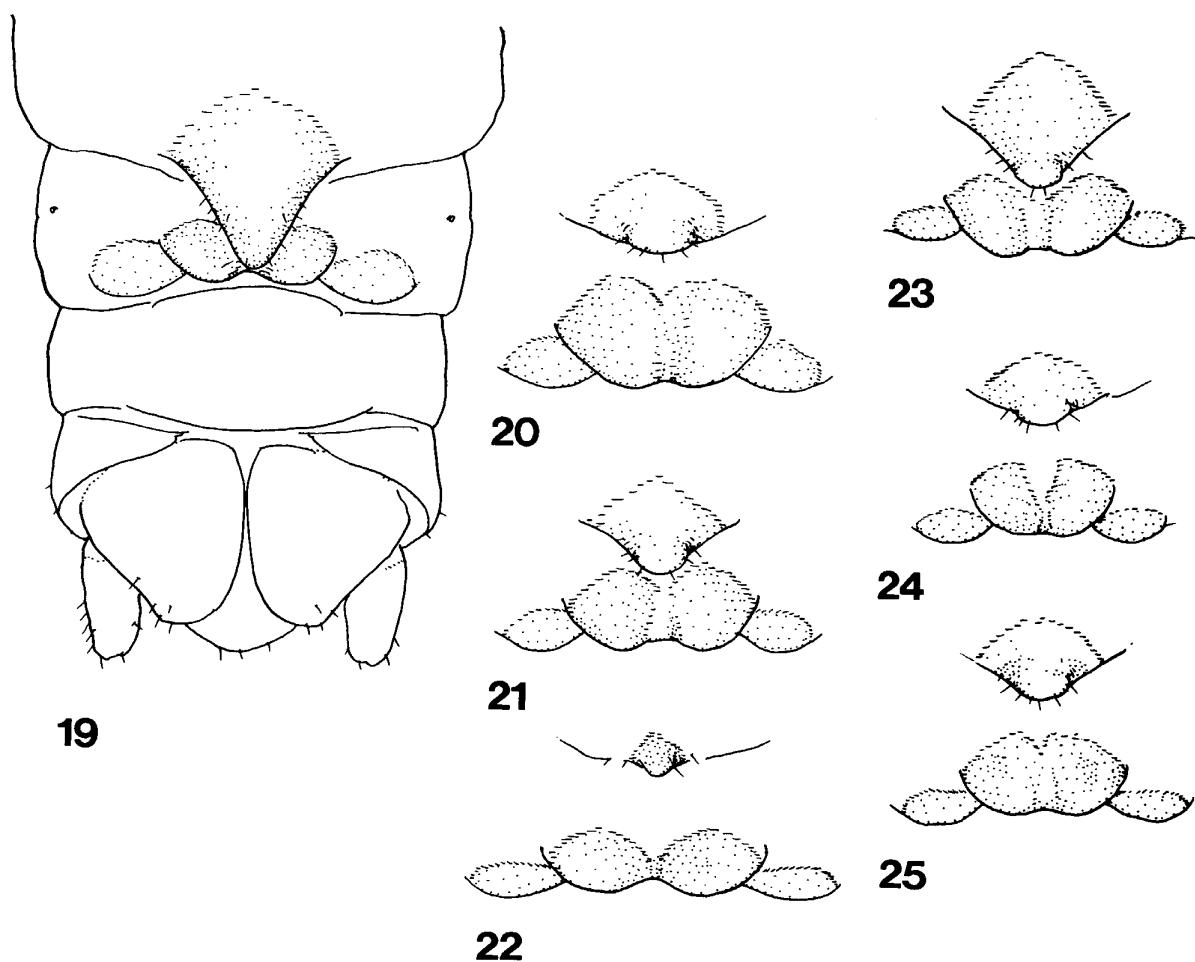
Wings subhyaline and weakly infuscated brownish; veins dark brown. General color dark brown: antennae, head, and thorax mostly dark brown. Legs: coxae and trochanters brown; femora yellowish with darker areas, hind femora brown in distal areas and dorsally in about basal 1/2; tibiae light brown and darker at both ends; tarsi dark.

Male. Abdominal tergites mostly membranous except for terminalia, tergites II to VII each with sclerotized fields anterolaterally. Sternite IX with an oblique vesicle; subgenital plate subpentagonal with bluntly elongated posterior corner. Tergite VIII bearing few to several setae posteromedially. Tergite IX bearing about a dozen setae around posteromedial membranous field. Tergite X with many small, scattered setae on either side of round membranous field below apex of epiproct. Cerci conical. Paraprocts: median lobe bulging out, bearing slender tigellus extending from inner side to acute tip slightly curved inward; outer lobe slender, elongated upward to angularly bulging apex, this bearing a few long setae on top and ventral side. Epiproct thin (dorsoventrally flattened) and slender, with blunt flagellum at apex; shallow groove along midline of dorsal face; ventral sclerite wide at base and tapered to apex, bearing many anterior setae on keel. Body length 6.0-7.5mm; forewing length 8.0-9.5mm.



Figs 13-15. *Protoneura hotakana* (Uéno): 13 and 14, male terminalia, dorsal and ventral views; 15, male epiproct, lateral view. Figs 16-18. *P. hakkodana* sp. n.: 16 and 17, male terminalia, dorsal and ventral views; 18, male epiproct, lateral view. Abbreviations: fl, flagellum; vs, ventral sclerite.

Female. Sternite VII forming small pregenital plate in middle of hind margin, latter sometimes peculiarly projected posteriorly. Sternite VIII with pair of small vaginal lobes and rounded subgenital plate, latter provided with shallow groove along midline and notch in middle of hind margin. Body length 7.0-9.5mm; forewing



Figs 19-25. Female terminalia (or pregenital and subgenital plates) of *Protonemura hotakana* (Uéno), ventral view, 19, from Shimashimadani; 20, Mitô-sawa; 21, Noro-gawa; 22, Chausu-dake; 23 Nishikayabe. Pregenital and subgenital plates of *P. hakkodana* sp. n.: 24, from Hakkôda Mts.; 25, Toyamazawa-gawa.

length 9.0-11.0mm.

Variation. The females vary individually and from place to place in the shape of the pregenital plate and subgenital plate. The pregenital plate distinctly projects backward in the original illustration and in the present specimens from Shimashimadani, Nagano. However, the subgenital plate varies in size and shape, and usually projects more weakly in specimens from other places (Figs 22-23).

Remarks. The species is very similar to *P. hakkodana* sp. n., but the male has a distinctive epiproct and paraprocts; i.e., it has a slender epiproct and tigellus and long setae at the apex of the outer lobe, while the male of *P. hakkodana* has a short, thick tigellus on the paraproct and short setae at the apex of the outer lobe.

The original description and illustrations by Uéno (1931) agree with both this and the next species, but he illustrated long setae on the apex of the male paraproct, which are one of the diagnostic features of this species.

Specimens examined. [Honshu] Ibaraki: Daigo-machi, Yamizo, 560m, 31.x.1992, 1F; Tochigi: Nikkô-shi, Okunikkô, Toyamazawa-gawa, 1,200m, 19.ix.1993, 16♂;

Tokyo: Hinohara-mura, Mitô-sawa, 3.xi.1990, 2♀; Okutama-shi, 10.ix.1984, K. Burnham, 1♀ (BYU); Yamanashi: Ashiyasu-mura, Noro-gawa, 10-11.x.1994, T. Hattori, 2♂ 5♀; Nagano: Matsumoto-shi, Shimashima-dani, 9.x.1994, 1♂ 2♀; Hotaka-chô, Shinanozaka, 10.x.1994, 2♀; Shizuoka: Shizuoka-shi, Chausu-dake, 800-2,000m, 8-10.x.1991, 1♂ 1♀ (BYU), 4♂ 16♀; Okayama: Kamisaibara-son, Nakatsuka-gawa, 9.xi.1993, 1♀; Kamisaibara-son, Onbara-kôgen, 10.xi.1993, 1♂ 5♀; Kawakami-son, Nishikayabe, 25♂ 7♀; Chûka-son, Yamanori-keikoku, 9.xi.1993, 4♀.

***Protonemura hakkodana* sp. n.**

Figs 16-18, 24, 25

Similar in general features to *P. hotakana* as described above, but different in the following characters:

Male. Paraprocts: median lobe with short tigellus elongated backward to blunt tip; outer lobe slender, elongated upward to rounded apex with several short setae on lateral side. Epiproct thin but slightly bent upward near apex; ventral sclerite wide at base and tapered, bearing many setae anteriorly in weakly convex area. Body length 6.0-7.5mm; forewing length 8.0-9.5mm.

Female. The female is difficult to separate from that of *P. hotakana*, and I have merely listed the specimens below according to the males collected with them at the same localities. Body length 7.0-10.0mm; forewing length 9.0-11.0mm.

Holotype. ♂ (LBM), Honshu, Aomori, Aomori-shi, Hakkôda Mts., 1,400m, 29.ix.1992. **Paratypes.** 3♂ 13♀ (LBM), collected with holotype.

Additional specimens. [Honshu] Tochigi: Kuroiso-shi, Ô-kawa, 21.ix.1993, 1♂; Kuroiso-shi, Kinomata-gawa, 21.ix.1993, 1♂; Nikkô-shi, Okunikkô, Toyamazawa-gawa, 17 and 28.ix.1991, H. Kato, 4♂ 17♀; *ditto*, Toyamazawa-gawa, 19.ix.1993, 39♂ 6F; *ditto*, Jigoku-gawa, 20.ix.1993, 22♂ 1♀; Nagano: Azumi-mura, Norikura Mts., Marishiten, 8.ix.1994, 1♂ 2♀.

Etymology. The specific epithet refers to the type locality, the Hakkôda Mountains.

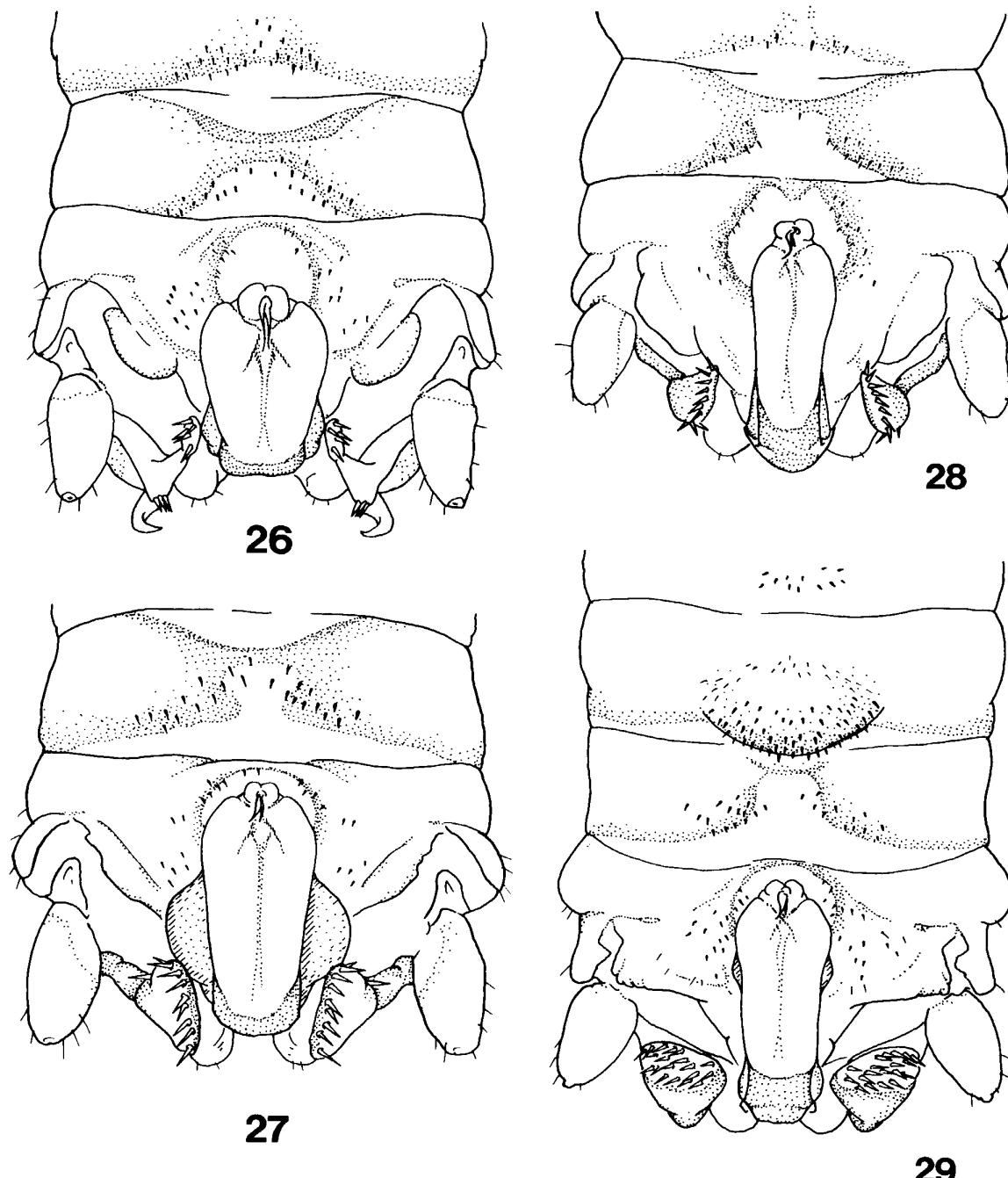
***Protonemura orbiculata* group**

***Protonemura orbiculata* sp. n.**

Figs 27, 33, 36

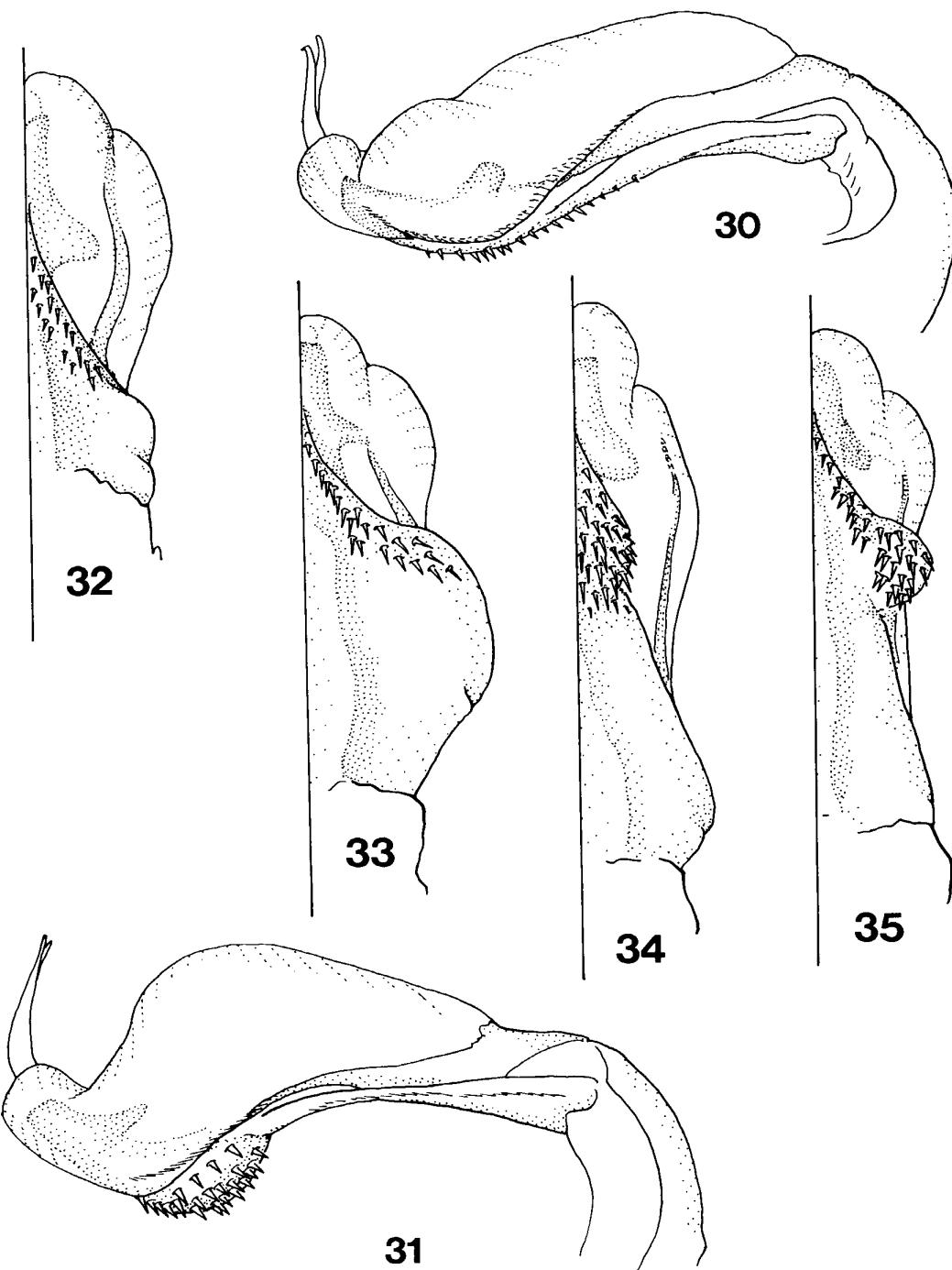
Wings weakly infuscated light brown; veins dark black. General color brown: head dark brown; pronotum brown with dark markings; thorax dark brown but sometimes with light brown area on anteromedial parts of nota and pleural regions. Legs: brown on coxae, trochanters, and tarsi; each femur mostly yellow but brown on distal end, with brown lines on dorsal face and on either side; tibiae pale but darker at both ends.

Male. Abdomen mostly membranous except for terminalia, but tergites II to VI with pair of sclerotized fields along their anterior margins. Tergites IV or V to VII with a few to several posteromedial setae. Tergites VIII and IX broadly sclerotized and bearing many setae posteromedially, both segments with median membranous field posteriorly. Tergite X concave below apex of epiproct, with about 12 setae



Figs 26-29. Male terminalia, dorsal view: 26, *Protonemura angulata* sp. n.; 27, *P. orbiculata* sp. n.; 28, *P. baumannii* sp. n.; 29, *P. seticollis* sp. nov.

scattered on each side around membranous field anterior to this concavity. Sternite IX: vesicle stout; subgenital plate narrow at base and dilated to rounded hind margin with elongated, blunt tip. Cerci conical. Paraprocts: median lobe convex, with long tigellus on inner side; tigellus extending upward and curving inward near tip; outer lobe extended upward, bulbous apex bearing about 10 bristles in a row. Epiproct: disk-shaped ventral sclerite visible in dorsal aspect, with many setae beneath anterior margin of disk. Body length 6.0-7.5mm; forewing length 7.5-9.0mm.



Figs 30-31. Male epiproct, lateral view: 30, *Protonemura angulata* sp. n.; 31, *P. seticollis* sp. n. Figs 32-35. Male epiproct (left side), ventral view: 32, *P. angulata* sp. n.; 33, *P. orbiculata* sp. n.; 34, *P. baumanni* sp. n.; 35, *P. seticollis* sp. n.

Female. Pregenital plate small, weakly convex medially. Subgenital plate normal, depressed along midline and convex laterally; vaginal lobes large and convex. Body length 7.0-9.5mm; forewing length 8.5-11.0mm.

Remarks. The species is similar to *P. angulata* sp. n., *P. baumanni* sp. n., and *P. seticollis* sp. n., but differs in the color of the wings, i.e., uniformly infuscated in this

species, only along the veins in the others. The male differs from those of the other species in having a distinctly expanded ventral sclerite of the epiproct. The female is similar to those of *P. angulata* and *P. baumannii*, but separable from them in the shape of the subgenital plate, which is shallowly concave in the middle of the hind margin.

Holotype. ♂ (LBM), Honshu, Ishikawa, Torigoe-mura, Kazuse, Dainichi-gawa, 250m, 5.iii.1993. *Paratypes.* Ishikawa, Torigoe-mura: 10♂ 6♀ (LBM), collected with holotype; 10♂ 2♀, Sareki, Dainichi-gawa, 200m, 4,5.iii.1993; 1♂, Betsumiya, Dainichi-gawa, 200m, 5.iii.1993.

Additional specimens. [Honshu] Aomori: Aomori-shi, Hakkôda Mts., 29.v.1990, 1♂ 5♀; Iwate: Kamaishi-shi, Hakusuisô Lodge, 18.xii.1982, K. Burnham, 1♂ (BYU); Fukushima: Aizuwakamatsu-shi, Ashinomaki, 21.iii.1983, K. Burnham, 1♂ 2♀ (BYU); Tokyo: Hinohara-mura, Kazuma, 26.iii.1990, 2♂ 1♀; Yamanashi: Enzan-shi, Ichinose, 8.iv.1990, 26.v.1990, 2♂ 4♀; Nagano: Kijimadaira-mura, Kayanodaira, 6.v.1991, S. Suda, 1♂; Ishikawa: Kanazawa-shi, 3-6.iii.1993, 54♂ 27♀; Kawachi-son, Okuike, 8.v.1991, 2♂ 7♀; Mie: Misugi-son, Hirakura, 400m, 23-24.iii.1992, 2♂; Kayano-chô, Yunoyama, 400m, 25.iii.1992, 1♀; Shiga: Kutsuki-son, Jayagamine, 500m, 27.iv.1992, 2♂ 1♀. [Shikoku] Tokushima: Kisawa-son, Tsurugidake, 1,400m, 3.iv.1991, 1♂ 1♀.

Etymology. The name comes from the Latin adjective *orbiculatus*, meaning circular and referring to the shape of the epiproct in dorsal aspect.

***Protonemura angulata* sp. n.**

Figs 26, 30, 32, 37

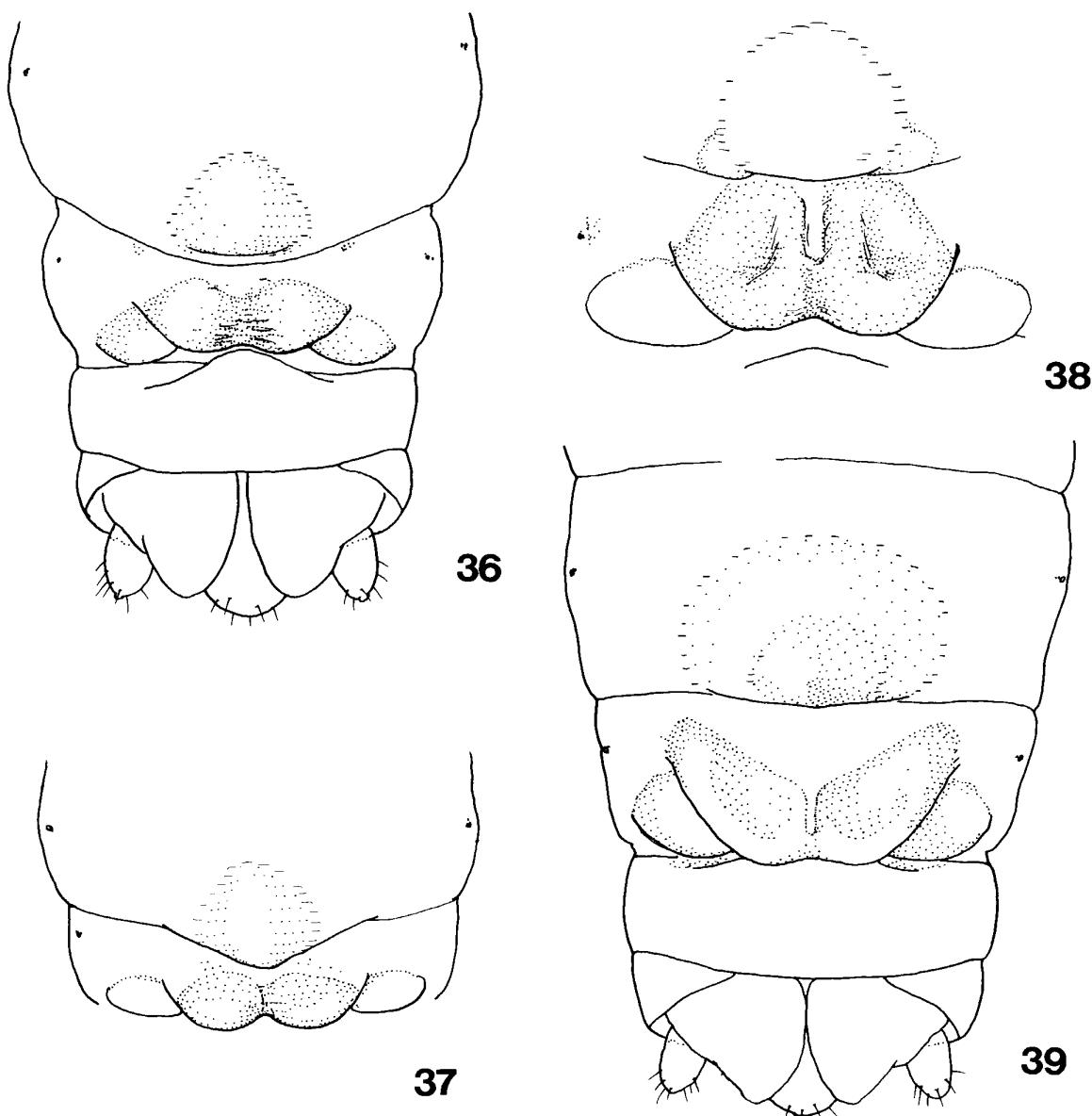
Wings subhyaline except for weakly brownish areas near dark black veins. General color brown: head dark brown; pronotum brown with dark markings; thorax dark brown with light brown areas on anteromedial parts of nota and pleural regions. Legs: brown on coxae, trochanters, and tarsi; each femur yellow with brown areas dorsobasally and distally; pale on tibiae with dark basal areas.

Male. Paraprocts: median lobe with long tigellus extending upward (a few setae on apex of tigellus in specimen from Tateya-sawa); outer lobe extending upward to angular corner bearing several stout setae, then elongated forward to rounded dorsal apex with several setae. Epiproct swollen and rounded; ventral sclerite wide near base then tapering toward apex, bearing many setae in apical half; dorsal sclerite elongated apically along lateral margins, reaching nearly to apex of epiproct. Body length ca. 7.0mm; forewing length 9.0-10.0mm.

Female. Pregenital plate moderate, rounded, and surface almost flat. Subgenital plate with rounded and medially notched hind margin; vaginal lobes large, weakly convex. Body length ca. 9.5mm; forewing length ca. 11.0mm.

Remarks. The species is similar to the two following species, but the male differs in having an epiproct without lateral swellings and an angular paraproct. The female is similar to those of *P. baumannii* sp. n. and *P. orbiculata* sp. n., but separable from the former in having a rounded pregenital plate, and from the latter in having a medially incised subgenital plate.

Holotype. ♂ (LBM), Honshu, Yamagata, Kaminoyama-shi, Mt. Zaô, 800m, 21.v.1992. *Paratypes.* 1♂ 1♀ (LBM), Honshu, Aomori, Aomori-shi, Hakkôda Mts., Torigoe-sawa, 29.v.1990; 1♂, Yamagata, Higashitagawa-gun, Tateya-sawa, 3.v.1994,



Figs 36-39. Female terminalia (or sternites VII and VIII), ventral view. 36, *Protonemura orbiculata* sp. n.; 37, *P. angulata* sp. n.; 38, *P. baumannii* sp. n.; 39, *P. seticollis* sp. n.

Y. Watanabe.

Etymology. From the Latin word *angulatus*, meaning angular, and referring to the shape of the paraproct.

***Protonemura baumannii* sp. n.**

Figs 28, 34, 38.

Similar in general respects to *P. angulata* as described above.

Male. Paraprocts: median lobe suboval and convex, with long, stout, apically forked tigellus on inner side; outer lobe extending upward, its apex swollen and

bearing 7-10 bristles along ridge. Epiproct: ventral sclerite wider near base and slightly tapering to apex, bearing many setae on weakly convex area near apex; inner arm branching from ventral sclerite to near apex, wide and expanded laterally. Body length 8.0-8.5mm; forewing length 9.5-10.0mm.

Female. Pregenital plate small, gently protruding posteriorly in middle of hind margin. Subgenital plate large, with medial groove and notch in middle of hind margin. Vaginal lobes large and transversely oval. Females from Kumaishi-chô all differing in shape of pregenital and subgenital plates, despite all of them being teneral (= recently molted condition, showing soft, pale-colored exoskeleton): pregenital plate rounded and not protruding posteriorly. Subgenital plate shallowly indented in middle of hind margin. Body length 9.0-9.5mm; forewing length 10.5-11.0mm.

Remarks. The species is similar to *P. angulata* sp. n. and *P. seticollis* sp. n., but the male differs in the shape of the epiproct, which has a weak anterior elevation with setae. The female is similar to those of *P. angulata* and *P. orbiculata*, but separable from the former in having an angular hind margin of the pregenital plate, and from the latter in having a subgenital plate with a sharp dent in the middle of the hind margin.

Holotype. ♂ (LBM), Hokkaido, Sapporo-shi, Misumai, Kannon-sawa, 11-25.v.1993, N. Kuhara, Malaise trap. *Paratypes.* Hokkaido: 1♂ 4♀ (LBM), collected with holotype; 1♂, same locality as holotype, 19.iv.1992, N. Kuhara; 2♀, same locality as holotype, 25.v-9.vi.1993, N. Kuhara, Malaise trap; 1♂ (BYU), Sapporo-shi, Toyohira-gawa, above Jôzankei, 4.v.1973, R. W. Baumann and T. Kumata; 1♂, Eniwa-shi, Ichankoppezawa, 10-20.v.1996, T. Ito, Malaise trap; 2♂ 3♀ (LBM), Kumaishi-chô, Kenichi-gawa, 11-21.iv.1995 and 1-26.iv.1996, Y. and T. Ito, Malaise trap.

Etymology. This species is named in honor of Dr. Richard W. Baumann, a famous plecopterist, who was one of its first collectors.

***Protonemura seticollis* sp. n.**
Figs 29, 31, 35, 39

Similar in general respects to *P. angulata* sp. n., but differing in color of femur (mostly yellow but with brown lines on dorsal face and brown at distal end) and color of wings (more widely infuscated near veins).

Male. Tergites VI and VII with few to several posteromedial setae. Tergite VIII elevated obliquely in middle of hind margin and possessing many short setae. Paraprocts: median lobe with slender tigellus extending backward and sometimes with a few branches at tip; outer lobe expanded inward and upward, apex swollen and bearing a dozen setae on dorsal face, and bearing a seta on ventral tip. Epiproct slender; ventral lobe roundly expanded near apex and bearing setae laterally along apex to the expansion. Body length 8.0-9.5mm; forewing length 11.0mm.

Female. Pregenital plate expanded, weakly sclerotized. Subgenital plate large, expanded posteriorly, and depressed in posteromedial area; vaginal lobes swollen and bulging. Body length 9.0-10.5mm; forewing length 12.5-14.5mm.

Remarks. This species is similar to the three preceding species, but the male differs in its modified tergite VIII, its epiproct, which has a rounded expansion with setae, and the dilated paraproct. The female is separable from those of the other

species in having distinctively enlarged pregenital and subgenital plates.

Holotype. ♂ (LBM), Honshu, Tochigi, Nikkō-shi, Okunikkō, Toyamazawa-gawa, 1,200m, 10.vi.1991, H. Kato. *Paratypes.* Tochigi, Nikkō-shi, Okunikkō, Toyamazawa-gawa, 1,200m: 1♂ 1♀ (LBM), collected with holotype; 3♂ 3♀ (LBM), 2♂ 3♀, 17.v, 16,21.vi, 3,8,11.vii, and 11, 17 and 28.ix.1991, H. Kato, emergence trap.

Etymology. The species name is a compound Latin, *seta* + *collis*, meaning setose hump and referring to the shape of male tergite VIII.

***Protonemura towadensis* group**
***Protonemura towadensis* (Kawai, 1954)**
 Figs 40-43

Nemoura (Protonemura) towadensis: Kawai 1954: 57, fig. 6 [Holotype M, Towadako, Aomori, Honshu, Japan]; Kohno 1957: 4 (checklist); Kawai 1960: 119 (key and additional records).

Protonemura towadensis: Illies 1966: 244 (catalogue); Kawai 1967: 14 (redescription and additional records), figs 4 and 6; Kawai 1976: 20 (catalogue); Zwick 1990: 246 (redescription of holotype and diagnosis), fig. 1.

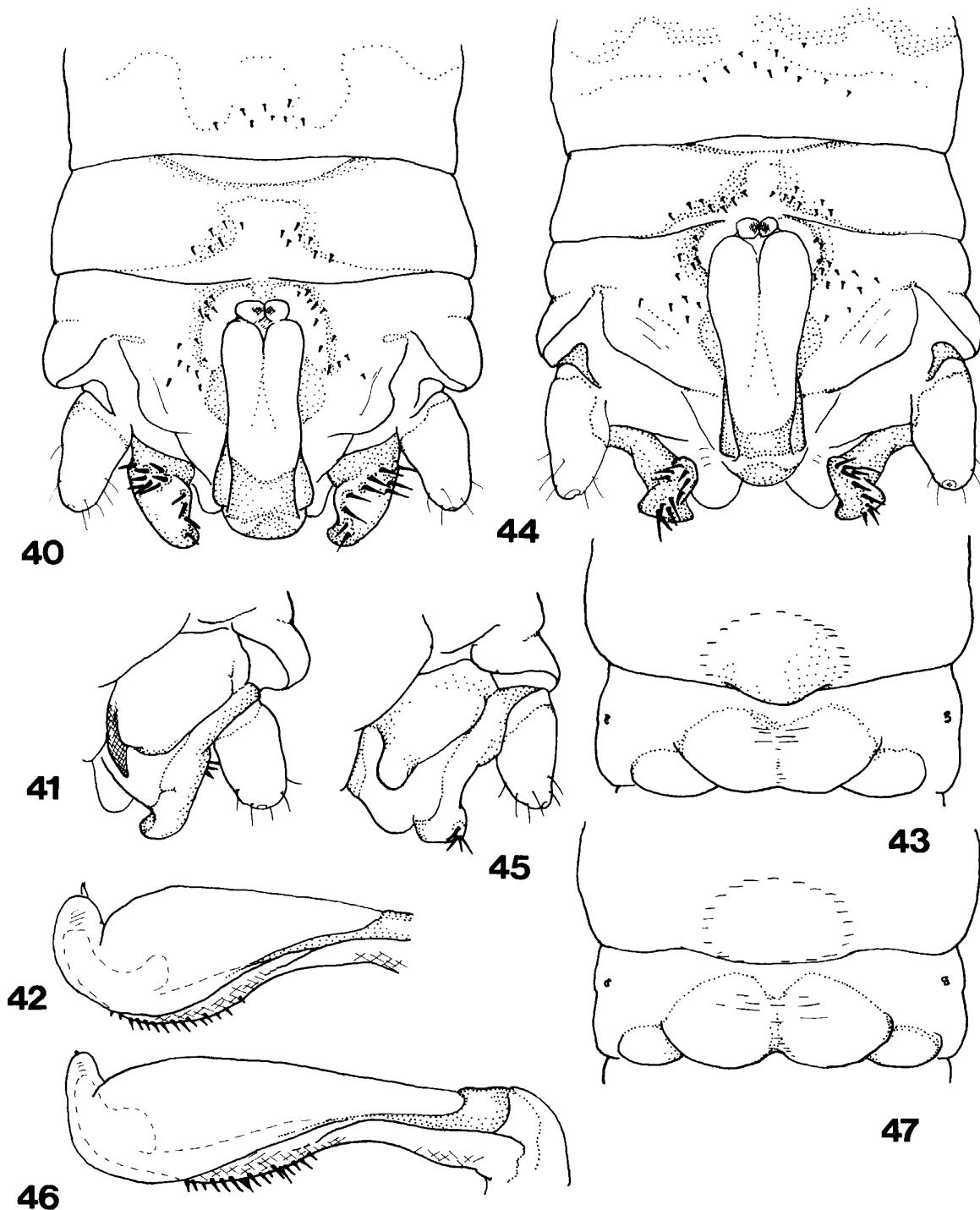
Wings subhyaline; veins dark brown. General color dark brown: antennae, head, and palpi dark brown; pronotum brown with weak humps; pterothorax dark brown. Legs: coxae and trachanters brown, femora yellow except brown in distal quarter, tibiae and tarsi light brown.

Male. Abdomen mostly membranous except for terminalia; anterior margins of tergites II-VII weakly sclerotized. Tergite VII with a few setae in posteromedial area. Tergites VIII and IX widely sclerotized but membranous posteriorly, bearing several setae in middle of hind margin. Tergite X bearing short, scattered setae anterolaterally around membranous field, anterior to concavity below epiproct. Sternite IX: vesicle large and oval; subgenital plate moderately wide at base, expanding to angular corners, and then obliquely terminating, with an elongated blunt tip at posteromedial end. Cerci conical and simple. Paraprocts: inner lobe small and simple; median lobe weakly convex and rounded, with short, blunt tigellus on inner side; outer lobe extending backward to subtriangular apex, bulging dorsally and posteriorly, concave on inner side and bearing about 12 setae on posterior edge and outer side. Epiproct: apex erect with short flagellum; ventral sclerite gently convex and bearing many setae anteriorly. Body length 6.0-7.0mm; forewing length 8.0-9.0mm.

Female. Pregenital plate small, weakly protruding in middle of hind margin. Subgenital plate well developed, weakly convex in middle of hind margin; vaginal lobes large and oval. Body length 7.0-9.0mm; forewing length 10.0-11.0mm.

Remarks. The species closely resembles *P. kohnoae* sp. n. and *P. ermolenkoi* Zhiltzova, described below, but the male is distinct in having a short tigellus. The female is difficult to distinguish from those of the other species, but it differs from that of *P. kohnoae* in the shape of the hind margin of the pregenital plate.

Specimens examined. [Honshu] Aomori: Kamikita-gun, Sarukura-onsen, 30.ix.1992, 1♂ 1♀ (BYU), 2♂ 1♀; Akita: Ōta-machi, Maki-keikoku, 7.x.1990, 1♂ 1♀; Tochigi: Nikkō-shi, Okunikkō, Toyamazawa-gawa, 1,200m, 18.x and 17.xi.1991 and



Figs 40-43. *Protoneura towadensis* (Kawai, 1954): 40 and 41, male terminalia, dorsal and ventral views; 42, epiproct, lateral view; 43, female sternites VII and VIII, ventral view. Figs 44-47. *Protoneura kohnoae* sp. n.: 44 and 45, male terminalia, dorsal and ventral views; 46, epiproct, lateral view; 47, female sternites VII and VIII, ventral view.

19-20.ix.1993, H. Kato, emergence trap, 24♂ 31♀; Nikkō-shi, Okunikkō, Jigoku-gawa, Tsumeta-sawa and Yanase-gawa, 20.ix.1993, 21♂ 2♀; Kuroiso-shi, 21.ix.1993, 24♂ 2♀; Okayama: Chūka-son, Yamanori-keikoku, 9.xi.1993, 1♂; Kamisaibara-son, Onbara-kōgen, 10.xi.1993, 3♂ 1♀; Kawakami-son, Kamiyufune, Yufune-gawa, 8.xi.1993, 2♂. [Kyushu] Ōita: Shonai-chō, Kurotake, Ōike, 20.v.1993, N. Kuhara, 1♂ 13♀.

Biological notes. This species appears to emerge mostly in the autumn although the adult is sometimes found in the spring; on the contrary, the adult of *P. kohnoae* sp. n. is collected mostly in the spring and rarely in the autumn. In my personal view, the two species have perhaps been confused in earlier accounts (e.g., Kawai 1960, 1967), although the present species has been collected in both spring and autumn.

***Protonemura kohnoae* sp. n.**

Figs 44-47

Similar in general respects to *P. towadensis* as described above, but different in the following characters:

Male. Paraprocts: inner lobe small and simple; median lobe tapering to roundly protruding apex, without tigellus; outer lobe extending posteriorly to enlarged apex with medial depression on inner flank and about 12 setae along margin dorsal to posterior edge. Epiproct long with slightly dilated tip; apex slender, erect; flagellum rudimentary and very difficult to see; ventral sclerite weakly convex medially. Body length 6.0-6.5mm; forewing length 8.0-9.0mm.

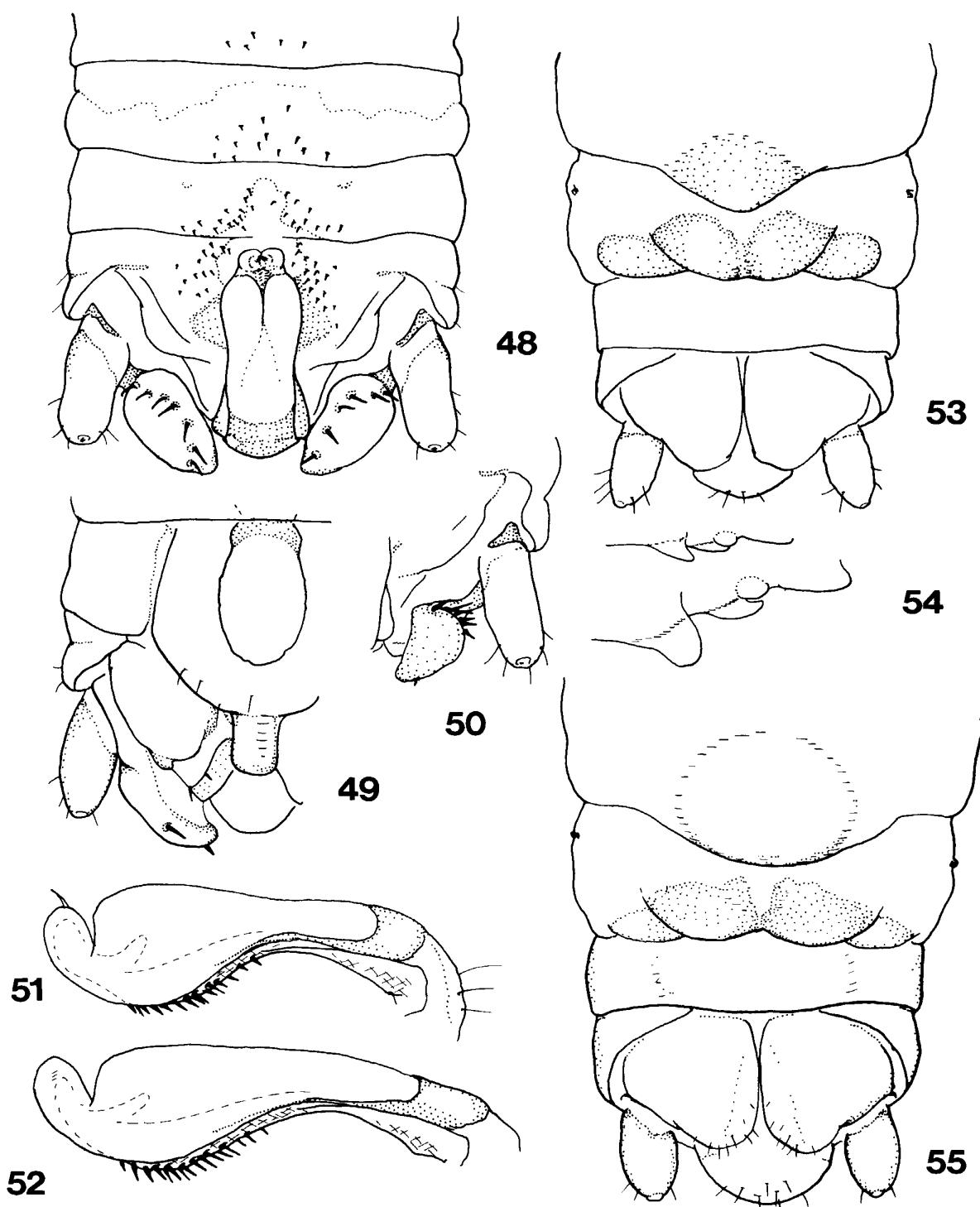
Female. Pregenital plate rounded, usually not protruding posteriorly. Subgenital plate well developed, variable in shape; vaginal lobes rounded and weakly convex. Body length 7.0-9.0mm; forewing length 10.0-11.0mm.

Remarks. The species closely resembles *P. towadensis* and *P. ermolenkoi*, but the male is distinct in having an elongate epiproct with a relatively small recurved apex, and in the laterally depressed apex of the paraprocts. The female is difficult to distinguish from those of the other species, but differs from that of *P. towadensis* in the almost even hind margin of the pregenital plate.

Holotype. ♂ (LBM), Honshu, Aomori, Aomori-shi, Hakkōda Mts., Jigokuike, Aka-gawa, 29.ix.1992. *Paratypes.* 8♂ 7♀ (LBM), collected with holotype.

Additional specimens. [Honshu] Aomori: Aomori-shi, Hakkōda Mts., 28-30.v.1990 and 1.vi.1990, 3♂ 2♀; Akita: Ogachi-chō, Yunomata-onsen, 1.x.1992, S. Niitsu, 1M; Fukushima: Inawashiro-shi, 5.v.1973, R. W. Baumann and M. Kohno, 90♂ 80♀ 29 nymphs (BYU); Tochigi: Nikkō-shi, Okunikkō, Toyamazawa-gawa, 8.vi-17.vii.1991 and 10.vi.1992, H. Kato, emergence trap, 19♂ 28♀; Nikkō-shi, Okunikkō, Jigoku-sawa, 11.vii.1991 and 17.vii.1993, H. Kato, 2♀; Yamanashi: Enzan-shi, Ichinose, 12.vi.1991, R. Kuranishi, 1♀; Nagano: Ueda-shi, iv.1990, H. Kato, 2♂ 2♀ 11 nymphs; Toyama: Hida Mts., Kurobe-gawa, above 2,000m, 27-29.vii.1990, 6♂ 5♀; Mie: Kamikitayama-chō, Ōdaigahara, 25-27.vi.1992, K. Matsumoto, 1♂.

Etymology. This species is named in honor of the late Dr. Mitsuko Kohno, who was a famous Japanese plecopterist.



Figs 48-54. *Protonemura ermolenkoi* Zhiltzova, 1982: 48 and 49, male terminalia, dorsal and ventral views; 50, variation of paraproct, dorsal view; 51, epiproct, lateral view; 52, variation of epiproct; 53, female terminalia, ventral view; 54, sternites VII and VIII, normal (above) and variation (below) in lateral views. Fig. 55. *Protonemura* spec. A, terminalia, ventral view.

***Protonemura ermolenkoi* Zhiltzova, 1982**

Figs 48-54

Protonemura ermolenkoi: Zhiltzova 1982: 42, fig. 3 [Holotype M, Sakhalin, Russia]; Zhiltzova and Zapekina-Dulkejt 1986: 212 (key).

Similar in general respects to *P. towadensis* as described above, but differing in the following characters:

Male. Paraprocts: inner lobe small and simple; median lobe gently convex, without tigellus; outer lobe extending backward to enlarged, suboval apex bearing regular row of long setae. Epiproct with apex turned dorsoapically; ventral sclerite with angular convex area anteriorly. Body length 5.0-6.5mm; forewing length 7.0-8.0mm.

Female. Pregenital plate protruding in posteromedial area, but transversely elliptical in specimens from some localities. Subgenital plate convex, weakly grooved along midline, and hind margin gently indented in middle. Vaginal lobes large and weakly convex. Body length 6.5-8.0mm; forewing length 9.0-10.0mm.

Variation. The male paraproct has a subtriangular apex and bears several setae only on the anterior field in some specimens (Fig. 50). The females are variable in the shape of the pregenital plate: it usually has an angular hind margin protruding posteriorly, but it is rounded in some specimens. Individuals collected in the spring differ in other ways from specimens collected in the autumn: the male has an epiproct without a visible flagellum at the apex (Fig. 54) and the female has a pregenital plate that distinctly protrudes ventrally (Fig. 52). I have listed the male and female specimens collected in the spring under 'additional specimens' below, regarding them as problematic. This species was originally erected for three males collected in July and September, and a September male was designated as the holotype.

Remarks. This species is similar to the two preceding species, but the male differs in the shapes of the paraproct and epiproct, i.e., the paraproct is rounded in ventral aspect and has a suboval apex, and the epiproct has its apex extended rather far anteriorly. The female is difficult to distinguish from those of the other two species, but usually it differs in having a pregenital plate with an angularly convex hind margin, although this feature is variable.

Specimens examined. [Hokkaido] Sapporo-shi: Misumai, Kannon-sawa, 24.ix.1992, N. Kuhara, 5♂ 2♀; Eniwa-shi: Kitakashiwagi, 27.x.1986, T. Ito, 8♂ 3♀; Tomakomai-shi: Takaoka, 27.ix.1986 and 6.xi.1991, R. Kuranishi, 1♂ 3♀; Furubira-chō: Tōmaru-tōge, 28.ix.1996, 4♂ 3♀; Kamoenai-son: Komayoshizawa, 27.ix.1996, 20♂ 8♀.

Additional specimens. Eniwa-shi: Izari, tributary of Ichankoppe-zawa, 310m, 1-10.vi. and 21-30.vi.1994, T. Ito, Malaise trap, 2♂ 2♀ (LBM), Izari, Ichankoppe-zawa, 240m, 31.v-11.vii.1995, T. Ito, Malaise trap, 2♂ 2♀. (New to Japan.)

Undetermined Female: ***Protonemura* spec. A**
Fig. 55

Wings subhyaline, smoky brown; veins darker. Head, pronotum, and thorax

mostly dark brown. Legs: coxae brown; trochanters yellow with darker basal areas; each femur yellowish with brownish distal area; tibiae dark on both basal and distal ends; tarsi brown. Abdomen mostly membranous except for terminalia. Pregenital plate round, surface almost even; subgenital plate and vaginal lobes normal. Cerci suboval. Body length ca. 8.0mm; forewing length ca. 10.0mm.

This female appears not to be conspecific with any other species known from Japan, and it is probably of a new to science. However, it has no distinctive features in the terminalia and coloration. I note this female specimen merely as a new record for the genus *Protonemura* in the Ryukyu Islands, and its status will be clarified when additional materials are obtained.

Specimens examined. 1 ♀ (LBM), Ryukyus, Okinawa-jima, Kunigami-son, Yonaha-dake, headwaters of Okuma-gawa, 24.ii.1994.

Acknowledgements

I am grateful for generous support received from the Ryûichi Matsuda Foundation, Japan, in 1996. Thanks are also due to Yu Isobe (Nara Women's University, Nara), Tomiko Ito (Hokkaido Fish Hatchery, Eniwa), Hideo Kato (Toho University, Funabashi), and Richard W. Baumann (Brigham Young University, Provo, Utah), for their gifts or loans of some important specimens used in this study.

References

- Aubert, J. 1946. Les Plécoptères de la Suisse Romande. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 20: 7-108.
- Aubert, J. 1956. Contribution à l'étude des Plécoptères de Grèce. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 29: 187-213.
- Baumann, R. W. 1975. Revision of the stonefly family Nemouridae (Plecoptera): A study of the world fauna at the generic level. Smithsonian Contributions to Zoology 211: iii + 74 pp.
- Claassen, P. W. 1940. A catalogue of the Plecoptera of the world. Memoirs of Cornell University Agricultural Experiment Station 232: 235 pp.
- Illies, J. 1966. Katalog der Rezenten Plecoptera. Das Tierreich, Walter de Gruyter, Berlin 82: xxx + 632 pp.
- Kawai, T. 1954. Studies on the holognathous stoneflies of Japan, I: Six new species of Nemouridae. Mushi 26: 53-58.
- Kawai, T. 1960. Studies on the holognathous stoneflies of Japan, VI: A revision of the family Nemouridae. Mushi 34: 115-136.
- Kawai, T. 1967. *Plecoptera (Insecta), Fauna Japonica*. Biogeographical Society of Japan, Tokyo, 211 pp.
- Kawai, T. 1976. A catalogue of Japanese Plecoptera. Nara Hydrobiology 5: 5-46.
- Kohno, M. 1957. List of Japanese Plecoptera. Mushi no Kuni (special): 1-24. [In Japanese]
- Okamoto, H., 1922. Zweiter Beitrag zur Kenntnis der Japanischen Plecopteren. Bulletin of the Agricultural Experiment Station, Government-General of Chosen, Suigen 1: 1-46
- Shimizu, T. 1994a. *Indonemoura nohirae* (Okamoto, 1922) comb. nov., a new record with a redescription of *Amphinemura longispina* (Okamoto, 1922). Japanese Journal of Entomology 62: 619-627.

- Shimizu, T. 1994b. Taxonomic changes and synonyms for the East Asian species of the genus *Nemoura* (Plecoptera: Nemouridae). *Aquatic Insects* 16: 213-225.
- Shimizu, T. (In press) New name of *Amphinemura* for *Nemoura (Protonevra) spinosa* Kawai, with description of a new species from Japan (Plecoptera, Nemouridae). *Japanese Journal of Entomology*.
- Uéno, M. 1931. Einige neue Ephemeropteren und Plecopteren aus Mittel-Japan. *Annotationes Zoologicae Japonenses* 16: 91-104.
- Zhiltzova, L. A. 1981. Materials of the stonefly fauna (Insecta: Plecoptera) from Kuril Islands. Pp. 79-88. In: Levanidov, V.Ya. (Ed.) *Invertebrates in the Salmon River Ecosystems of the Far East*. Far Eastern Branch of the USSR Academy of Sciences, Vladivostok. 126 pp. [In Russian]
- Zhiltzova, L. A. 1982. New stonefly species (Plecoptera, Nemouridae) from the Far East. *Vestnik Zoologii* 1982 (2): 37-44. [In Russian with English summary.]
- Zhiltzova, L. A. and Zapekina-Dulkejt, Y. I. 1986. Order Plecoptera - Stoneflies. Pp. 172-234. In: Lehr, P. A. (Ed.) *Identification of the Insects of the Far East of the USSR, Vol. 1. Apterygota, Palaeoptera, Incomplete Metamorphosis*. Leningrad, Nauka, 452 pp. [In Russian]
- Zwick, P. 1990. Notes on Plecoptera (20): *Protonevra towadensis* (Kawai, 1954). *Aquatic Insects* 12: 246.